A3 Cont

29. The method for manufacturing a semiconductor device according to claim 8, wherein said semiconductor device has a MOSFET with a gate insulation film of a dielectric film, and wherein said CVD high melting point metal nitride layer is the lowermost layer of the laminated gate electrode layer formed on said gate insulation film.

REMARKS

This paper is being provided in response to the November 1, 2000 Office Action for the above-referenced application. In this response, Applicant has cancelled claim 12, amended Claims 1-11 and 13- 20, and added claims 21-29 in order to more particularly point out and distinctly claim that which Applicant deems to be the invention. Applicant respectfully submits that the modifications to the claims and the new claims are all supported by the originally filed application.

The rejection of Claims 1-20 under 35 U.S.C. §103(a) as being unpatentable over Nishikawa et al. (U.S. Patent No. 6,087,261, hereinafter referred to as "Nishikawa") in view of Tamaru et al (U.S. Patent No. 6,103,566, hereinafter referred to as "Tamaru") and further in view of Lee et al. (U.S. Patent No. 6,010,940, hereinafter referred to as "Lee") is hereby traversed and reconsideration thereof is respectfully requested. Applicant respectfully submits that Claims 1-11 and 13-20, as amended herein, are patentable over the cited references, whether taken separately or in any combination.

Claim 1, as amended herein, recites a method for forming a semiconductor device having a laminated structure of a dielectric film made from a metal oxide which is formed on a surface of a substrate and a CVD high melting point metal nitride film directly formed on the metal oxide. The metal nitride film is directly formed on the dielectric film

by introducing a source gas containing the high melting point metal into a chamber in which the substrate is contained. The method has a step of treating the substrate in the chamber wit a gas non-reactive with respect to the metal oxide and/or NH_3 gas. The method keeps the temperature of the substrate at a prescribed temperature, before the source gas containing the high melting point metal is introduced into the chamber. Claims 2 through 7 depend from claim 1 and recite that the treating step has a flow stabilizing step; the non-reactive gas is introduced during the flow stabilizing step; the treating step heats the substrate and the flow stabilizing step is after the heating step; the NH_3 gas is introduced into the chamber during the heating step; the NH_3 gas has a NH_3 partial pressure of no greater than 1.0 Torr and no less than 0.1 Torr; and the non-reactive gas and the NH_3 gas are introduced into said chamber during the flow stabilizing step.

Claim 8, as amended herein, recites a method for forming a semiconductor device having a laminated structure of a dielectric made from a metal oxide and a CVD high melting point metal nitride film formed. The metal nitride film is directly formed on the dielectric film by introducing a source gas containing the high melting point metal into a chamber in which the substrate is contained. The method heats a substrate to a prescribed temperature in an NH_3 atmosphere of no greater partial pressure than 1.0 Torr and no less than 0.1 Torr before the introduction of the source gas containing the high melting point metal. Claims 9-10 depend from claim 8 and recite a step of heating the substrate to a prescribed temperature and maintaining the temperature in a non-reactive gas with respect to the metal oxide and while the gas flow is stabilized; and the NH_3 gas being introduced during the substrate heating step or the flow stabilization step.

Claims 11 and 13-20 depend from claim 1 and recite a step of introducing the source gas containing the high melting point metal, and growing a CVD high melting point metal nitride film after performing said flow stabilization step, and raising the partial pressure of the NH_3 gas in the second half of the CVD film growing step so that annealing is done by the NH_3 gas; a step, performed before the CVD high melting point metal nitride film forming step, of heating a substrate onto which the dielectric film is formed, in the chamber by introducing the non-reactive gas; and a step of forming the high melting point metal nitride film on the dielectric film by introducing a gas mixture comprising the NH_3 gas and the non-reactive gas, the non-reactive gas larger than NH_3 gas, and the source gas less than the NH_3 and non-reactive gas; the dielectric film is a tantalum oxide (Ta_20_5) film; the substrate is heated to between approximately 400°C and 700°C; the non-reactive gas is selected from nitrogen, argon, hydrogen gas, or a mixture of these gases; the high melting point metal nitride film is a TiN film. Claim 17 recites that the source gas containing titanium is selected from the group consisting of titanium tetrachloride ($TiCl_4$), tetrakis dimethyl amino titanium (TDMAT), tetrakis diethyl amino titanium (TDEAT); the high melting point metal nitride film is alternately a WN film, and WF_6 gas is introduced as a source gas; and the semiconductor device has a capacitive element, a dielectric film, a CVD high melting point metal nitride film as a protective film disposed between the dielectric film and the capacitive element.

New Claims 21 - 29 recite raising the partial pressure of the NH_3 gas during a second half of forming the CVD film on the metal oxide, so that annealing is done by the NH_3 gas; the dielectric film is a tantalum oxide (Ta_2O_5) film; the substrate is heated between approximately 400°C and 700°C; the non-reactive gas is selected from nitrogen, argon, hydrogen gas, or a mixture of these gases; the high melting point metal nitride film is a TiN film; the source gas containing titanium is selected from the group consisting of titanium tetrachloride ($TiCl_4$), tetrakis dimethyl amino titanium (TDMAT), tetrakis diethyl amino titanium (TDEAT); the high melting point metal nitride film comprises a WN film, and WF_6 gas is introduced as a source gas containing tungsten;
the semiconductor device has a capacitive element, a dielectric film, and a CVD high melting point metal nitride film as a protective film between the dielectric film and capacitive element; and the semiconductor device has a MOSFET with a gate insulation film of a dielectric film, and the CVD high melting point metal nitride layer is the lowermost layer of the laminated gate electrode layer formed on the gate insulation film.

The cited art of Nishikawa discloses a method of forming a dielectric film on a semiconductor substrate in a reduced pressure atmosphere, and depositing a metal or metal nitride on the dielectric. The reference discloses that hydrogen, carbon and methane released during CVD deposition may cause leakage in the dielectric, and that this is reduced by using oxygen containing gases in the formation of the conductor film (Col. 2, lines 18-27; Col. 4, line 66; Col. 9, line 15) which is stated to be extremely important (Col. 2, line 63). The reference discloses that using a reaction gas that contains oxygen at up to 5 sccm (Col. 5, line 23) produces an oxygen containing metal film that

does not have too high a resistivity to be a useful conductor. The oxidizing gas may be selected from oxygen, peroxide, water, ozone, carbon monoxide, carbon dioxide, nitrous oxide etc (Col. 5, line 35 and Col. 14, line 47) with the amount kept low through the middle stage of the formation of the conductor (Col. 3, line 12) to keep the metal resistance high enough to be a good conductor (Col. 4, line 60 and Fig 2).

The cited art of Tamaru discloses a DRAM with a capacitive element that is protected from breakdown under the influence of a TiN film that is CVD deposited on the capacitor dielectric by a passivation film, thus preventing the dielectric from contacting the nitrogen containing reducing gas (Col. 3, lines 25 and 49). The reference discloses the use of ammonia to passivate the polysilicon lower electrode (Col. 2, lines 10-24), but teaches away from any ammonia or reducing gas after the dielectric is formed (Col. 3, lines 30 and 49; Col. 4, line 20) until after a oxygen containing titanium source gas has covered the metal oxide (Col. 18, lines 33- 40 wherein it teaches that the metal oxide should not come into contact with the reducing gases such as ammonia).

The cited art of Lee discloses a method for making a TiN barrier for a capacitor upper plate to reduce the reactions between the metal oxide and the polysilicon upper electrode (Col. 1, line 26). The TiN layer is disclosed as being formed using TiCl4, which may form a material that may attack the metal oxide. This chlorine mat be reduced by use of an ammonia anneal which chemically attacks the chlorine and removes it as HCl gas. The anneal is disclosed as occurring after the TiN deposition.

Applicant respectfully submits that the Nishikawa reference teaches using a oxidizing ambient to form a slightly oxidized metal layer through about the middle of the conductor formation, in order to prevent the disassociation of the metal oxide film by a reducing ambient. The reference teaches using an oxidizing ambient and not an inert

ambient. The cited reference does not teach or suggest treating the surface of the metal oxide with an inert ambient, and the use of the inert gas He is disclosed as being used with oxygen prior to the deposition of the metal oxide during a chamber purging step, and not to treat the metal oxide before metal deposition. Thus the cited reference not only does not describe or suggest the method of the present application, but further teaches away from the use of ammonia since a reducing gas is discussed as part of the problem.

Applicant respectfully submits that the Tamaru reference teaches and claims using a oxidizing titanium source gas ambient to form a metal layer prior to the introduction of any reducing gas such as ammonia, in order to prevent the disassociation of the metal oxide film by a reducing ambient. Thus the cited reference not only does not describe or suggest the method of the present application, but further teaches away from the use of ammonia since it is a reducing gas is discussed as part of the problem.

Applicant respectfully submits that the Lee reference teaches an anneal that occurs after a small thickness of a TiN barrier layer is formed, and thus does not describe or suggest an anneal of the metal oxide or the use of TiN as an electrode. Thus the cited reference of Lee does not provide motivation for one of skill in the art to combine it with the other cited art since it is directed towards a chemical removal of residual chlorine gas in a vacuum system, and not towards protecting the metal oxide film from reducing ambients as the other two cited references.

The cited prior art generally discloses methods to protect a metal oxide film from reducing ambients, or methods to remove unwanted residual absorbed chlorine gas. The cited references, whether taken either alone or in any combination, do not provide one of ordinary skill in the art with motivation to combine them. Nor does the suggested combination provide the suggested motivation to use nitrogen to prevent reoxidation of

the tantalum oxide, as suggested in the Office Action, because two of the references are concerned with the reduction of the tantalum oxide, as noted above, and not with the reoxidation of tantalum oxide, and the third reference is concerned with chlorine attack of the tantalum oxide.

Therefore, for reasons set forth above, Applicant respectfully requests that this rejection be withdrawn.

Based on the above, Applicant respectfully requests that the Examiner reconsider and withdraw all outstanding rejections and objections. Favorable consideration and allowance are earnestly solicited. Should there be any questions after reviewing this paper, the Examiner is invited to contact the undersigned at 617-951-6676.

Respectfully submitted,
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